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published in
Developmental Medicine and Child Neurology
2011

DOI (link to publisher)
10.1111/j.1469-8749.2010.03806.x

citation for published version (APA)
Emck, C., Bosscher, R. J., van Wieringen, P. C. W., Doreleijers, T. A. H., & Beek, P. J. (2011). Gross motor performance and physical fitness in children with psychiatric disorders. *Developmental Medicine and Child Neurology*, *53*(2), 150-155. https://doi.org/10.1111/j.1469-8749.2010.03806.x

Gross motor performance and physical fitness in children with psychiatric disorders

CLAUDIA EMCK[1] | RUUD J BOSSCHER[1] | PIET CW VAN WIERINGEN[1] | THEO DORELEIJERS[1] | PETER J BEEK[2]

1 Research Institute MOVE, Faculty of Human Movement Sciences, VU University, Amsterdam, the Netherlands. **2** Department of Child and Adolescent Psychiatry, VU University Medical Centre, Amsterdam, the Netherlands.

Correspondence to Claudia Emck, Faculty of Human Movement Sciences, VU University, Amsterdam, Van der Boechorststraat 9, 1081 BT Amsterdam, the Netherlands. E-mail: c.emck@fbw.vu.nl

This article is commented on by Cairney on pages 104–105 of this issue.

PUBLICATION DATA
Accepted for publication 6th August 2010.
Published online 21st October 2010.

ABBREVIATIONS

DISC	Diagnostic Interview Schedule for Children
DISC-P	Diagnostic Interview Schedule for Children – parent version
CSBQ	Children's Social Behaviour Questionnaire
GMQ	Gross Motor Quotient
MOPER	Motor Performance test
PDD	Pervasive developmental disorders
TGMD-II	Test of Gross Motor Development

AIM Gross motor performance appears to be impaired in children with psychiatric disorders but little is known about which skill domains are affected in each disorder, nor about possible accompanying deficits in physical fitness. The present study has sought to provide information about these issues in children with emotional, behavioural, and pervasive developmental disorders (PDD).

METHOD One hundred children receiving psychiatric care (81 males, 19 females, mean age 9y 11mo, SD 1y 8mo) completed both the Test of Gross Motor Development, measuring locomotion and object control, and the Motor Performance test, measuring neuromotor and aerobic fitness. The emotional disorders, behavioural disorders (BD), and PDD subgroups consisted of 17, 44 and 39 children respectively.

RESULTS The mean gross motor performance scores of the BD and PDD group were significantly ($p<0.05$) lower than the score of the emotional disorders group, but even the latter score was significantly lower ($p<0.05$) than the population norm score. Physical fitness was poor in all subgroups. The subdomains locomotion and object control were unusually highly correlated in the PDD group ($r=0.68$). Moreover, only in the PDD group were the locomotion scores significantly correlated with neuromotor fitness ($r=0.47$, $p=0.02$).

INTERPRETATION The specific combinations of impairments in gross motor skills and physical fitness in children with psychiatric disorders indicate the importance of the assessment of these domains in order to provide interventions tailored to the specific profile of each individual child.

No one doubts the importance of gross motor skills like running, jumping, throwing, and catching for children participating in games and sports.[1–3] Children who perform poorly participate less in physical activities and practice less than their peers, which may widen the skill gap and lead to activity deficits and poor physical fitness.[3–6]

Clinical observations suggest that many children with psychiatric disorders show impaired gross motor performance. To date, research on this topic has been predominantly confined to children with attention-deficit/hyperactivity disorders (ADHD), pervasive developmental disorders (PDD), and, to a lesser extent, emotional disorders.[7–10] The majority of these studies confirmed the clinical observations: on average, children with psychiatric disorders perform worse on gross motor tests than typically developing children. However, nearly all pertinent studies reported only overall scores on motor tests and practically no scores on more specific domains of motor skill. An exception is the study of Erez et al.,[9] who reported balance skill deficits in children with anxiety disorders.

Impaired gross motor skills are known to be related to poor physical fitness, which in turn is associated with impaired health status.[5,6,11,12] There are indications that children with ADHD often have poor physical fitness.[10] However, to our knowledge, no studies focused specifically on the physical fitness of children with emotional or pervasive developmental disorders have been published to date. It thus remains unknown if gross motor impairments in children with psychiatric disorders are associated with specific fitness components, such as strength, speed, flexibility, or aerobic fitness.[12] If so, this would be of great importance for the development of interventions.

The purpose of the present study was to determine how different aspects of gross motor performance and physical fitness are affected in three psychiatric subgroups: children with emotional disorders, behavioural disorders, and PDD. In line with previous research,[8] we expected children with PDD to show the most severe impairments in gross motor performance, followed by children with behavioural disorders and children with emotional disorders. In view of the relations between psychiatric disorders and motor problems on the one hand and between motor problems and physical fitness on the other hand, it was expected that physical fitness of children with

 DOI: 10.1111/j.1469-8749.2010.03806.x

psychiatric disorders would be low. Physical fitness was assessed with the Motor Performance test (MOPER)[13] and gross motor performance was measured with the Test of Gross Motor Development (TGMD-II).[14]

METHOD

Participants

Between 2004 and 2007, a cross-sectional study was performed in which data were collected of 145 children, aged 6 to 12 years, with a range of psychiatric disorders from six child psychiatric centres in the Netherlands. All children were referred by their general practitioner and Diagnostic and Statistical Manual of Mental Disorders, 4th edition[15] classified by a registered child psychiatrist who also informed their parents about the study. Parents received information letters, so did their children, and about two-thirds of the parents and children agreed to participate in the study. Reasons for non-participation were mainly of a practical nature; the parents and children in question already had too many appointments and assessments and were therefore unable to participate.

The children were tested by two trained examiners, during which the accompanying parent participated separately in the Diagnostic Interview Schedule for Children (DISC) and filled out the Children's Social Behaviour Questionnaire (CSBQ). In view of the relatively long duration of the diagnostic interview–parent version (DISC-P), the assessment was distributed over two sessions. Children who were diagnosed with both an emotional and a behavioural or other disorder were excluded, as were children for whom the clinical diagnosis could not be confirmed by the DISC or CSBQ. The final sample consisted of 100 children: 38 males and 14 females received inpatient care while 43 males and five females received outpatient care. All parents gave their written consent for participation. The study was approved by the Medical Ethics Committee of VU University Amsterdam.

Measures

Psychiatric disorders were diagnosed by means of the Dutch version of the Diagnostic Interview Schedule for Children–parent version (DISC-P)[16] and the Children's Social Behaviour Questionnaire (CSBQ).[17] The DISC-P is a highly structured parent interview for obtaining psychiatric diagnoses, except for PDD, with adequate reliability and validity.[16] The CSBQ is a questionnaire for parents used for identifying specific symptom patterns of PDD. The validity and reliability of the CSBQ and its subscales are satisfactory.[17] Four out of six subscales refer to the core deficits in PDD: (1) reduced social contact and interest, (2) difficulties in understanding social information, (3) stereotyped behaviour, and (4) fear of and resistance to changes. For the present study, only children with a clinical diagnosis of PDD who scored in or above the average category for the PDD norm group on at least three of the four subscales were classified as PDD.

Gross motor performance was measured with the TGMD-II.[14] According to the manual, reliability and validity of the TGMD-II are adequate.[14] The test entails two subtests, locomotion and object control, each based on six separate skills.

What this paper adds

- Children with emotional, behavioural, and pervasive developmental disorders (PDD) show specific patterns of impairments in gross motor performance and physical fitness.
- Children with PDD show severe and highly intercorrelated gross motor and physical fitness impairments.
- Children with these psychiatric disorders require individually tailored interventions targeting gross motor and physical fitness impairments.

The locomotion skills are: run, gallop, hop, leap, horizontal jump, and slide. The object control skills are: striking a stationary ball, stationary dribble, catch, kick, overhand throw, and underhand roll. Raw scores are converted to standard scores (mean 10, SD 3), age equivalents, and to an overall Gross Motor Quotient (GMQ: mean 100, SD 15). Norm scores are available for both males and females aged 3 to 11 years.[14] Because no significant differences were found in GMQ, locomotion, or object control between 11- and 12-year-old children compared to 9- and 10-year-old children, we used the norms for the 9- and 10-year-old children for the older children as well.

Physical fitness was measured by the MOPER,[13] which consists of items that measure different aspects of neuromotor and aerobic fitness. Strength measurements were the 'flexed-arm hang' (the maximal time that the participants' eyes are above a horizontal bar in a hanging position), the 'standing high jump' (the maximal jumping height in metres, measured with a jump board, measuring tape, and belt), and 'ten leg lifts' (the time in seconds needed to lift the legs 10 times from the horizontal to vertical position with extended knees). Speed measurements were 'ten times 5m sprint' (the time in seconds needed to run 10 times between two lines, placed 5m apart) and 'plate tapping' (the time in seconds needed to tap 50 times with the participants' preferred hand between two plates positioned 75cm apart). The flexibility measurement was a 'sit and reach test' (the maximal reach in centimetres in the sitting position with extended knees). Apart from these neuromotor tasks, aerobic fitness was measured using the 'six-minute run', in which the child ran around a 150m court. The distance covered during 6 minutes was registered.

Norm scores were provided in 1982 for Dutch children aged 9, 10, and 11 (males and females separately); the category scores (1–5) relate to quintiles with regard to the population norms. The reliability and validity of each subtest were adequate.[13] Although an overall score is sometimes used as an indicator of neuromotor fitness, no norm scores for this variable are available. Therefore, confining the analysis to the participants in the age range of 9 to 11 years, we used the mean of the category scores on the six neuromotor items as an indicator of neuromotor fitness (neuromotor score, range 1–5). Furthermore, the mean category score of arm hang, high jump, and leg lift was used as an indicator of overall strength, while the mean category score of running speed and plate tapping was used as an indicator of overall speed. Although using norms dating back from 1982 poses no problem for comparisons between groups and for correlational analyses, it may be problematic if comparisons are made with typically developing children given a worldwide decline in physical fitness of children since the 1980s.[18] Therefore, we also compared the raw MOPER fitness scores with recent scores from a large Dutch community sample of 9- to 11-year-old children.[12] These scores were only available for the neuromotor fitness subtests, but not for the 6-minute run indicating aerobic fitness.

Subgroups

For the analysis at group level we constructed three groups: (1) emotional disorders, this group consisted of children diagnosed with at least one DISC anxiety disorder and/or a dysthymic or depressive disorder, (2) behavioural disorders, consisting of children with DISC diagnoses ADHD, oppositional defiant disorder, and/or conduct disorder, (3) PDD, this group consisted of children with CSBQ-diagnosed PDD.

Statistical analysis

Means and standard deviations are provided for the main dependent variables (GMQ, locomotion and object control standard scores, developmental delay of locomotion and object control, neuromotor fitness, overall strength, overall speed, and MOPER subtest scores). A 'motor delay' score for locomotion and object control was computed to assess the developmental delay (real age minus gross motor age equivalent).

To compare the participants with children in the normal population, one-sample *t*-test was performed and effect sizes were calculated using $r_{es}=\sqrt{(t^2/t^2+df)}$. Effect sizes were interpreted as large when $r_{es}\geq 0.50$).[19] Since in all cases, Levene's tests showed that parametric assumptions about the distribution of the data in the subgroups were not violated ($p>0.05$), differences between subgroups were analysed by means of ANOVAs. Differences between each of the three subgroups were analysed by Games-Howell tests, because these post-hoc tests are regarded as the most accurate and powerful ones available in case of unequal sample sizes.[20] Correlations between locomotion and object control scores were calculated, followed by Fisher *r*-to-*z* transformation to compare correlation coefficients within the subgroups with those within the norm sample.[14]

For subgroups, correlations were computed between MOPER scores (neuromotor fitness, overall speed, and overall strength) and TGMD-II measures (GMQ, locomotion, and object control).

Finally, for the boys aged 9 to 11 years, pooled variance estimate *t*-tests were performed on MOPER neuromotor fitness subtests to compare the mean scores per age group with the mean scores of a community sample recently provided by Runhaar et al.[12] As no data of this sample were available for the 6-minute run, comparisons for the aerobic fitness subtests were not made. The number of participants in our sample was too small to consider the diagnostic groups separately within each age band; hence the comparisons were only made at the level of the psychiatric group as a whole.

RESULTS

Descriptive information about sex, distribution of inpatients and outpatients and the use of medication across the subgroups is presented in Table I. Males and females did not differ significantly in age ($t(98)=0.66$, $p>0.10$). There were neither significant differences between the subgroups, emotional disorders, behavioural disorders and PDD with regard to age ($F_{2,97}=1.6$, $p>0.10$) nor with regard to the number of inpatients and outpatients ($\chi^2(2)=2.36$, $p=0.307$; Table I).

Mean GMQ, locomotion, and object control scores of all subgroups differed significantly from the norm population (Table II). Subgroups differed in GMQ ($F_{2,97}=3.90$, $p=0.023$); the emotional disorders group had a significantly higher GMQ than both the behavioural disorders group ($p=0.025$) and the PDD group ($p=0.007$). Subgroups differed on the locomotion subtest ($F_{2,97}=4.31$, $p=0.02$); the emotional disorders group scored significantly better than the PDD group ($p=0.008$) and the behavioural disorders group ($p=0.05$). No significant differences between subgroups were found for object control ($F_{2,97}=1.64$, $p=0.20$). Locomotion and object control scores were significantly correlated in the behavioural disorders and PDD group, but not in the emotional disorders group. The correlation coefficient in the PDD group differed significantly from those in the norm group ($z=2.31$, $p=0.02$), the emotional disorders group ($z=2.76$, $p=0.01$), and the behavioural disorders group ($z=2.03$, $p=0.04$). All subgroups showed marked delays in motor development for about 3 years.

For the MOPER, only data of the children aged 9 to 11 years ($n=53$, 43 males, 10 females) were analysed. All subgroups scored below average (<3) on all fitness subtests (Table III). No significant differences in neuromotor fitness between the subgroups were found ($F_{2,50}=2.3$, $p=0.11$).

Analyses for emotional disorders and behavioural disorders separately showed no significant correlations between MOPER (overall neuromotor fitness, overall speed, overall strength) and TGMD-II measures (GMQ, locomotion, object control). However, in the PDD group the overall neuromotor score correlated significantly with locomotion ($r=0.47$, $p=0.02$), and a trend towards significance was found for the

Table I: Participants and subgroups

						Medication, *n* (%)		
	n	Males	Females	Mean age (SD), y:mo	*n* (%) inpatients	Methylphenidate	Melatonin	Atypical antipsychotics
Emotional disorders	17	12	5	10:6 (1:6)	6 (35)	0	0	0
Behavioural disorders	44	39	5	9:10 (1:10)	25 (57)	8 (18)	3 (7)	2 (4.5)
Pervasive developmental disorder	39	30	9	9:8 (1:7)	21 (54)	7 (18)	8 (21)	10 (31)
Total	100	81	19	9:11 (1:8)	52 (52)	15 (15)	11 (11)	12 (12)

Table II: GMQ, locomotion, and object control on Test of Gross Motor Development for each subgroup

	Emotional disorders (n=17)				Behavioural disorders (n=44)				Pervasive developmental disorders (n=39)			
	Mean (SD)	t	p	r_{es}	Mean (SD)	t	p	r_{es}	Mean (SD)	t	p	r_{es}
GMQ[a]	89.94 (11.0)	3.76	0.002	0.68	80.50 (14.58)	8.87	0.00	0.80	77.54 (17.6)	7.97	0.00	0.79
Locomotion[a]	8.53 (2.45)	2.47	0.025	0.53	6.73 (2.94)	7.37	0.00	0.75	6.10 (2.90)	8.39	0.00	0.81
Object control[a]	8.12 (2.83)	2.75	0.014	0.56	6.91 (3.06)	6.70	0.00	0.71	6.44 (3.49)	6.39	0.00	0.72
Locomotion & object[b]	−0.04				0.35[c]				0.68[d]			
Delay Locomotion	2:7 (2:4)				3:5 (2:7)				3:6 (2:6)			
Delay Object control	2:8 (1:10)				2:11 (2:4)				2:11 (2:8)			

[a]Mean scores on Gross Motor Quotient (GMQ), locomotion, and object control for each subgroup, followed by t-values indicating the difference with the population means. [b]Pearson correlations between locomotion and object control scores. Developmental delays in years and months with respect to locomotion, and object control for each subgroup. Population mean GMQ=100 (SD 15); population mean standard scores locomotion and object control=10 (SD 3). [c]$p<0.05$, [d]$p<0.01$.

Table III: Mean and standard deviation of subtests scores on Motor Performance test for each subgroup

	Emotional disorders (n=12)	Behavioural disorders (n=20)	Pervasive developmental disorders (n=21)
Neuromotor fitness	2.0 (0.6)	1.7 (0.6)	1.6 (0.5)
Overall strength	1.9 (0.8)	1.5 (0.6)	1.6 (0.6)
Arm hang	1.3 (0.4)	1.2 (0.4)	1.3 (0.6)
Standing high jump	2.6 (1.6)	1.6 (0.9)	2.2 (1.5)
Legs lift	2.1 (1.6)	1.8 (1.5)	1.4 (0.8)
Overall speed	2.2 (1.1)	1.8 (0.9)	1.5 (0.7)
Running speed	1.8 (1.3)	1.3 (0.8)	1.1 (0.3)
Plate tapping	2.6 (1.6)	2.3 (1.4)	1.9 (1.3)
Flexibility: sit and reach	2.1 (1.6)	2.0 (1.3)	1.9 (1.2)
Aerobic fitness (6min run)	1.0 (0.0)	1.1 (0.3)	1.0 (0.0)

Score, 1=low, 2=below average, 3=average, 4=above average, 5=high; each category represents 20% of the norm population.

correlation with GMQ (r=0.40, p=0.07). Furthermore, in the PDD group GMQ was significantly correlated with overall strength (r=0.52, p=0.02).

Compared to the sample studied by Runhaar et al.,[12] the males in our sample performed significantly worse on neuromotor fitness subtests, except for leg lift in all age groups, plate tapping in 10- and 11-year-olds, and sit and reach in 9- and 10-year-olds (Table IV).

DISCUSSION

The aim of this study was to examine which aspects of gross motor performance and physical fitness are affected in children with psychiatric disorders. Large effect sizes of each disorder on gross motor performance were found that amounted to a developmental delay of approximately 3 years for both locomotion and object control, indicating that the psychiatric group performed significantly worse than typically developing children. Furthermore, children with psychiatric disorders were characterized by poor neuromotor and aerobic fitness. Although these findings pertained to all subgroups, some remarkable differences were present.

As expected, children with emotional disorders were less impaired in gross motor skills than children with behavioural disorders or PDD. Interestingly, and in contrast to healthy

Table IV: Mean and standard deviation scores on the Motor Performance test fitness items for 9- to 11-year-old males in research group and sample (Runhaar et al. 2009)

	Males 9-year-olds			Males 10-year-olds			Males 11-year-olds		
	Psy	R group	t_p	Psy	R group	t_p	Psy	R group	t_p
Arm hang in s	2.9 (2.0)	10.0 (9.6)	2.74[a]	2.8 (4.0)	12.9 (12.1)	2.76[a]	5.3 (6.0)	12.5 (9.4)	3.22[a]
n	14	51		11	356		18	444	
High jump in cm	25.9 (5.3)	34.2 (6.3)	4.50[a]	29.8 (5.2)	36.8 (5.7)	4.02[a]	31.2 (5.2)	38.7 (6.6)	4.63[a]
n	14	50		11	358		17	444	
10 legs lift in s	20.5 (7.5)	18.0 (5.6)	0.14[ns]	19.6 (6.9)	17.9 (6.4)	0.87[ns]	18.2 (4.5)	18.4 (6.7)	0.12[ns]
n	14	49		11	356		17	433	
Running speed 5m in s	22.8 (2.1)	20.2 (1.9)	4.42[a]	22.2 (3.1)	19.7 (1.5)	5.22[a]	21.2 (1.9)	19.4 (1.6)	4.52[a]
n	14	50		11	361		18	442	
Plate tapping in s	18.9 (2.9)	16.0 (1.7)	4.77[a]	16.1 (2.8)	15.6 (1.8)	0.89[ns]	14.9 (2.7)	14.8 (1.7)	0.24[ns]
n	14	50		11	357		18	441	
Sit and reach in cm	26.1 (5.9)	28.1 (7.3)	0.94[ns]	23.6 (6.0)	27.0 (6.4)	1.74[ns]	19.8 (8.6)	25.4 (6.8)	3.39[a]
n	14	51		11	359		18	440	
6min run in m	–	No data	–	–	No data	–	–	No data	–

[a]$p<0.01$. For arm hang, high jump, and sit and reach higher scores indicate better performance; for legs lift, running speed, and plate tapping lower scores indicate better performance. No data on 6min run were available for the sample of Runhaar et al. (2009). Psy, research group children with psychiatric disorders; R group, sample of Runhaar et al. (2009); t_p, pooled variance estimate t-test.

children,[14] locomotion and object control were unrelated, suggesting that children with emotional disorders show variable patterns of gross motor impairments. Since a neurologically based connection between balance dysfunction and anxiety in children has recently been documented,[9,21] these variable patterns might be due to differential effects of balance problems on locomotion and object control. Although the emotional disorders group performed better than the other subgroups on gross motor performance, they did not show higher physical fitness scores. Unfortunately, however, it could not be definitely ascertained whether the low fitness scores in the emotional disorders group really reflected low physical fitness. They might also have been due to subjective perceptions of low energy and self-defeating thoughts[22] resulting in a reduced motivation to participate in tasks that require effort and perseverance, like the MOPER. However, if children habitually fail to spend effort and to persist in physical activities, lower physical fitness might emerge as a consequence.

As expected, the PDD group showed the largest gross motor impairment of all subgroups in both locomotion and object control. Remarkably, the scores in these subdomains were significantly higher correlated in this subgroup than in the other subgroups and in typically developing children. Moreover, significant correlations between TGMD-II and MOPER measures were only found in the PDD group. These results are in agreement with earlier findings indicating abnormally high correlations between ability domains in children with PDD which have been tentatively interpreted as reflecting an underlying impairment in the development of connectivity of brain systems.[23]

Our expectation that children with behavioural disorders would perform better than children with PDD, but worse than children with emotional disorders was only partially confirmed. Gross motor performance was indeed more impaired in the emotional disorders than in the behavioural disorders groups, but the difference between the behavioural disorders group and the PDD group was not significant. Also, the effect sizes (0.80 and 0.79) were almost the same in behavioural disorders group and PDD group, as was the developmental delay in locomotion and object control. These findings illustrate the phenotypic similarities of these two groups and testify to the appropriateness of the ongoing debate whether these groups represent ecologically valid categories.[24,25] However, while locomotion and object control were strongly interrelated in the PDD group, their correlation in the behavioural disorders group fell within the normal range (between 0.34 and 0.48).[14] In this respect, the behavioural disorders group appeared more similar to typically developing children than to the PDD group, suggesting that the underlying neurodevelopmental mechanisms of these groups may be different.

Three limitations of the present study should be mentioned. First, some of the children were on medication. However, no adverse effects of the types of medication on gross motor performance are known. On the contrary, methylphenidate, used by 18% of the children in the behavioural disorders and PDD groups, might have led to better motor performance as a consequence of improved concentration on the gross motor tasks, thus leading to an underestimation of the gross motor impairment in these two groups. Second, we used the TGMD-II norms for 9- to 10-year olds for 11- to 12-year-old children as well. The fact, however, that the older children did not even live up to those norms highlights the significance of their motor problems. Third, although the MOPER fitness test is a widely used instrument to study physical fitness in children, the available norm data were outdated, which limited the interpretation of some of the results. In recognition of this problem, however, we also compared our data to recently published data of a community sample[12] and the results again confirmed our hypothesis that physical fitness in psychiatric children is typically rather poor.

This study shows that gross motor performance needs attention in child psychiatric practice regardless of the specific type of disorder. We therefore recommend a standard gross motor assessment for all children who receive psychiatric care in order to provide interventions tailored to the specific symptom profile of each individual child. If gross motor problems remain unnoticed, a widening skill-learning gap is likely to occur, which may hamper psychosocial development even further, which in turn may have negative influences on the course of the psychiatric disorder. Therefore, longitudinal studies, such as recently published by Cairney et al.,[6] are needed to track the development of gross motor performance and physical fitness in children with psychiatric disorders. Furthermore, in view of the low physical fitness of children attending psychiatric care, it is of great importance to enhance daily activity levels to prevent secondary health problems in these children in the long run.

ACKNOWLEDGEMENTS

We are especially grateful to all the children and their parents that participated in this study for their cooperation. We would like to thank the management of the six child psychiatric centres for providing their facilities: Symfora Group Fornhese, Amersfoort; De Jutters, Den Haag; De Bascule, Amsterdam; Karakter Het Eeveld, Ede; Curium, Leiden; Kores, Rotterdam.

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